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Ergonomically Evaluating Manual Fodder Cutter for Drudgery Reduction in Animal Husbandry

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ABSTRACT

Background: Fodder cutter is one of the agricultural equipment used to chop all kinds of green and dry fodder into small pieces to feed animals. Due to less cost and ease of operation, it is available in every household owning cattle. It is most common and widely available machines used twice a day to chopped the fodder. The previous study suggested that operation on existing fodder cutters is physically demanding because of the high energy requirement and continuous adoption of awkward work postures. The power required to cut the fodder by traditionally used fodder cutter was very high than power applied by the operator for cutting leads to high physiological demand and more energy expenditures throughout the degree of rotation flywheel.

Methods: The ergonomic assessment of traditional fodder cutter was done and compared with the fodder cutter having different number of blades. Fodder cutter with number of blades for cutting *i.e.* single, double, three and four blade and reduction in throat area by A, A/2, A/3 and A/4 from the existing fodder cutter, were taken for the study. The ergonomic evaluation of the manual fodder cutters in terms physiological parameters (oxygen consumption, heart rate and energy expenditure) during the chopping operation was measured.

Result: Fodder cutter with three blades and reduce throat area by A/3 from existing fodder cutter has minimum energy consumption while operating fodder cutter. From the study it was observed that the power required to chopped the fodder was less for three blade fodder cutter and it was ergonomically compatible for the operation.

Key words: Ergonomics, Livestock, Manual fodder cutter.

INTRODUCTION

India has largest livestock population in the world about 540 million and contributes 12% of world share of livestock (Livestock Census, 2019). Livestock contributes 32% of total agricultural GDP and support livelihood of about two-third rural population. According to livestock census, 2019 about 85% of farmers in India are small and marginal farmers having land holding less than 2 ha. These 85% of small and marginal farmers have about 45% of total operated area under cultivation and owner of 75% of animal husbandry. Since, maximum share of livestock in the country owned by small and marginal farmers and they have maximum 2-3 cattle to support their livelihood. They contribute additional income to the livelihood. Growing human population, rising per capital income and increasing urbanization are fueling rapid growth in demand for food and animal. Livestock contributes in the growth and development of agricultural sector. In present scenario most of the livestock work like washing, rearing, milking, bathing feeding are done by female farmers. Animal feeding is very important aspect of livestock husbandry. It is very necessary to have effective utilization of available feed sources. Chaff is hay cut into small pieces for feeding to livestock (Mohan and Kumar, 2004); it is a good fodder and it is clean and evenly cut, free of dust, of good color and with a fresh aroma. Chopped fodder aids the animal's digestion and prevents animals from rejecting any part of their food. To chopped the animal feed fodder cutter is only equipment owned livestock owner to chopped the fodder. In India manually operated fodder cutter is most available agricultural equipment in India and being used twice a day, every day to feed the cattle. Manually energized fodder cutter machines are environment-friendly *i.e.,* non-pollutants and available with almost all small land marginal farmers having cattle. It is easy to operate even unskilled men and women can also operate. Manually operated fodder cutter is the only agricultural equipment, which is used every day throughout the year by a large number of farming families (Kumar *et al.,* 2010). Cutting of crop into small pieces (crushing) then feeding to the livestock, increases the consumption and palatability of feed, hence reducing the wastage. But the existing equipment available is most drudgery prone, operated at very awkward postures and required large amount of extraneous energy. Chopping of fodder by operator is done manually which is

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physically demanding through its energy and postural requirements and is commonly regarded as source of drudgery (Kumar *et al*., 2004); many farmers associated with this task reported back, shoulder and wrist discomfort. (Kalaiselvan *et al.,* 2016). It may also cause clinical or anatomical disorders and may affect worker's health. Therefore, the available human energized fodder cutter has a scope for modification based on human power and energy requirement for cutting different fodders.

By considering this, the present study was intended to ergonomically evaluate the fodder cutter using a different number of fodders cutting blades (one, two, three and four) and reduced throat area by, full, half, one-third and one-fourth respectively and compare with the existing fodder cutter.

MATERIALS AND METHODS

The manual chaff cutter was ergonomically evaluated in terms of physiological parameters, heart rate, energy expenditure and human physiological power requirement. The selected subject were physically and medically fit to carry out the experiments and willing to participate in the experiments. Six subjects of age group 35-45 years were selected for the study, representing the largest percentage of workers on the farm. It was ascertained that the selected subject was physically fit and engaged in farm work, not having an illness, handicap or chronic problem.

To conduct the experiment the laboratory work was carried out in farm machinery and ergonomics lab and field work was conducted in the field of Division of Agricultural Engineering. The most common and widely used fodder namely, maize, jowar and bajra were selected for experiment and they were grown division field. All the three types of fodder were grown according to agronomical parameters of cultivation and harvested after recommended days of maturity of crop for feeding cattle.

Measurement of physiological energy required

Calibration of selected six subjects were done. The oxygen consumption was measured by sub-maximal testing on a treadmill and K4B2. Naughton protocol (Naughton *et al*., 1963) were followed to determine aerobic capacity. In this method, the straight line on the calibration chart was extended up to an estimated maximum heart rate of the subject which is equal to "220-age of the subject". The heart rate during the operation were recorded and oxygen consumption were obtained from calibration graph. A portable heart rate monitor was used to measure the heart rate during the fodder cutter operation by using different number of blades. The experiment was carried out for one hour continuously and then the rest were given to achieve the normal heart rate. The values of HR were taken for the calculation of working heart rate as the physiological responses of the subject. From the mean value of heart rate determined during the experiments, the corresponding values of oxygen consumption (VO_2) of the subjects for all experiments were determined from the linear relationship of HR and OCR. The energy expenditure during the experiments was computed by multiplying the oxygen consumption values with the calorific value of oxygen, which is 20.88 kJ^{-1} (Nag *et al*., 1980) for all six subjects operating four different fodder cutter.Physiological human power for different flywheels was measured by the product of energy expenditure and the number of flywheel rotations.

RESULTS AND DISCUSSION

Ergonomic evaluation of existing chaff cutter and four different combination of fodder cutter were done by recording the physiological parameters of operator: heart rate, energy expenditures and volumetric oxygen consumption. The calibration equation, subjects' age, volumetric oxygen consumption and maximum heart rate of the selected subjects are given in Table 1. The results for heart rate, oxygen consumption, energy expenditure and physiological power expended while cutting fodder are depicted in Fig 1, 2, 3 and 4.

The average heart rate was maximum for four blade and minimum for three blades *i.e.* 138 bpm and 129 bpm. The volumetric oxygen consumption was calculated by the calibration chart. From the calibration chart it was observed that maximum oxygen consumption was for four blades followed by single blade fodder cutter, conventional fodder cutter and two blade fodder cutter. The minimum oxygen

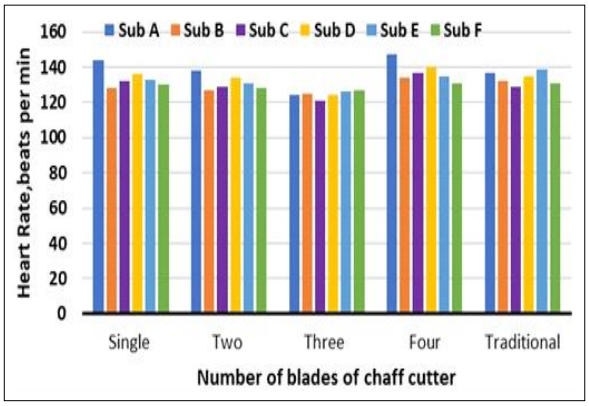


Fig 1: Heart rate subjects operating chaff cutter.

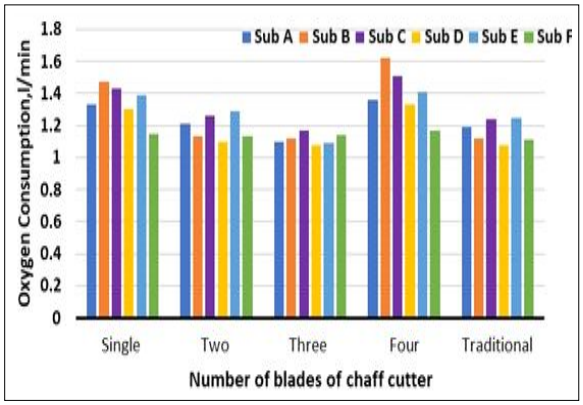


Fig 2: oxygen consumption of subjects operating chaff cutter.

Table 1: Calibration equation of subjects.

Sub	Age	Calibration equation	R^2	VO_2 max (l/min)	Maximum heart rate (bpm)
A	33	Y=0.0165X-0.748	0.946	1.84	187
B	45	Y=0.0216X-1.406	0.926	2.37	175
C	35	Y=0.0138X-0.391	0.902	2.16	185
D	36	Y=0.0173X-1.036	0.888	2.15	184
E	32	Y=0.0241X-1.132	0.955	3.39	188
F	28	Y=0.0169X-0.996	0.895	2.25	192

*X = Heart rate of subjects Y = Oxygen consumption of the subjects.

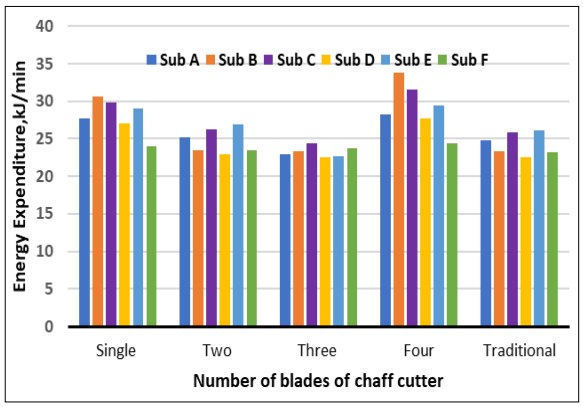


Fig 3: Energy expenditure by subjects operating chaff cutter.

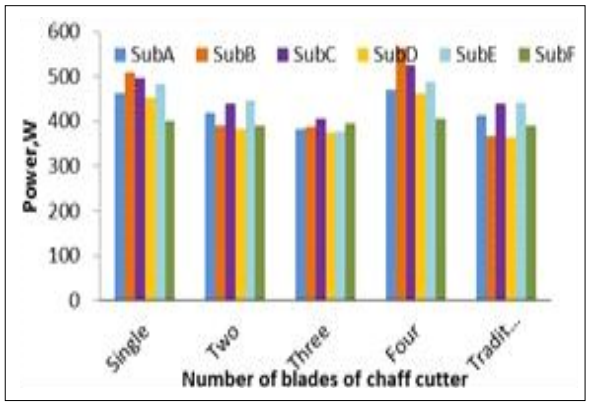


Fig 4: Physiological power expended by subjects operating chaff cutter.

consumption was for three blades. The energy expenditure was calculated by multiplying oxygen consumption values with the calorific values of oxygen as 20.88 kJ/min (Nag *et al.*, 1980). From the graphical representation, it was observed that energy expenditure for the three blades was lowest, which falls in the "moderate" workload while fodder cutter with single, two four blades and conventional chaff cutter were 28.03 kJ/min, 24.71 kJ/min, 29.18 kJ/min and 25 kJ/min respectively, lie under "Heavy" category workload. The power required by a human in cutting fodder was also calculated. The graph shows that the physiological power requirement for cutting was minimum for three blades and maximum for four blades fodder cutter.

CONCLUSION

The conventional manual fodder cutter and four different fodder cutter having variation in number of blades *i.e.* single, two, three and four were evaluated in terms of physiological parameters. The experiment was conducted by varying number of blades on flywheel *i.e.* one, two, three and four and respectively reducing the throat area by full, half, one third and one fourth from throat area of existing fodder cutter. The ergonomic assessment of operator were done in terms of heart rate, energy expenditure and physiological power requirement during manual cutting operation.. During work performance, the average heart rate of workers was 133 bpm, 131 bpm, 129 bpm and 138 bpm for single, two, three and four blades chaff cutter, respectively. The reduction in heart rate was maximum for three blades and there was almost a shift of the category of the workload from "heavy" to "moderate".

According to the least physiological power consumption and less mechanical power consumption, a three-blade chaff cutter with a 66 per cent reduction in throat size is more ergonomically compatible for the operator. It was observed that the energy expenditure for three blade was minimum and lie in "moderate work load". Therefore, according to experiment three blade fodder cutter with reduced throat area required less power in cutting and ergonomically compatible for the operator.

Conflict of interest: None.

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